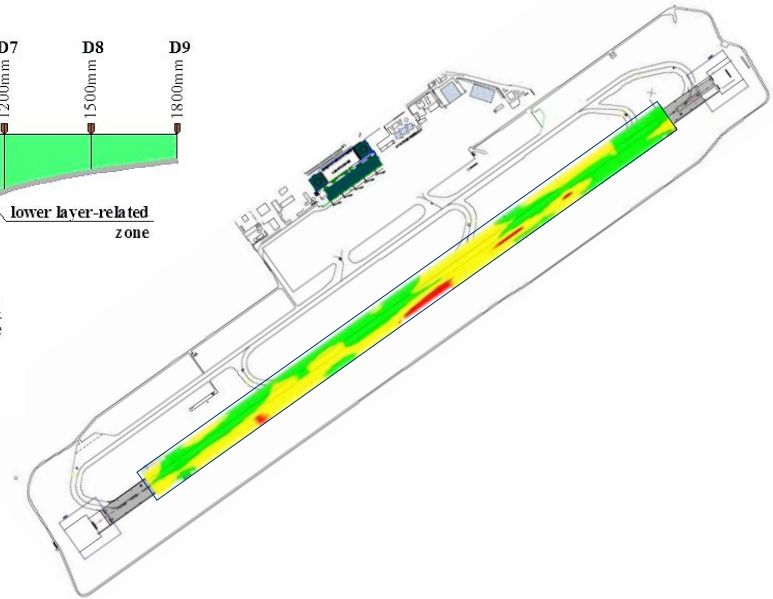
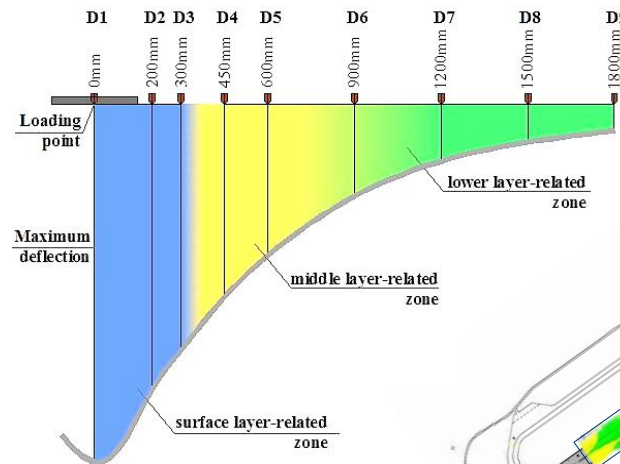




2014 FAA Worldwide Airport Technology Transfer Conference
August 5-7, 2014 – Galloway, New Jersey, USA

IMPLEMENTATION OF DEFLECTION BOWL MEASUREMENTS FOR STRUCTURAL EVALUATIONS AT NETWORK LEVEL OF APMS



Franco Pigozzi, Mauro Coni, Silvia Portas and Francesca Maltinti – University of Cagliari, Italy



DICAAR



- ▶ **Introduction**
- ▶ **Research Objective and Scope**
- ▶ **Testing location: The Olbia «Costa Smeralda» Airport**
- ▶ **Tests conducted**
- ▶ **Data analysis**
- ▶ **Benchmarking application**
- ▶ **Conclusions**

Introduction

RAPID AND EASY TECHNIQUES FOR
STRUCTURAL EVALUATION AT **NETWORK LEVEL**
OF APMS WITH LOW BUDGET REQUIREMENTS
FOR PAVEMENT EVALUATIONS

STRUCTURAL INVESTIGATIONS CAN BE
CONDUCTED WITH THE **F/HWD**, THEN
THE BACK-CALCULATION ALLOWS THE
LAYER STIFFNESS KNOWLEDGE

DIRECT USE OF DEFLECTION VALUES

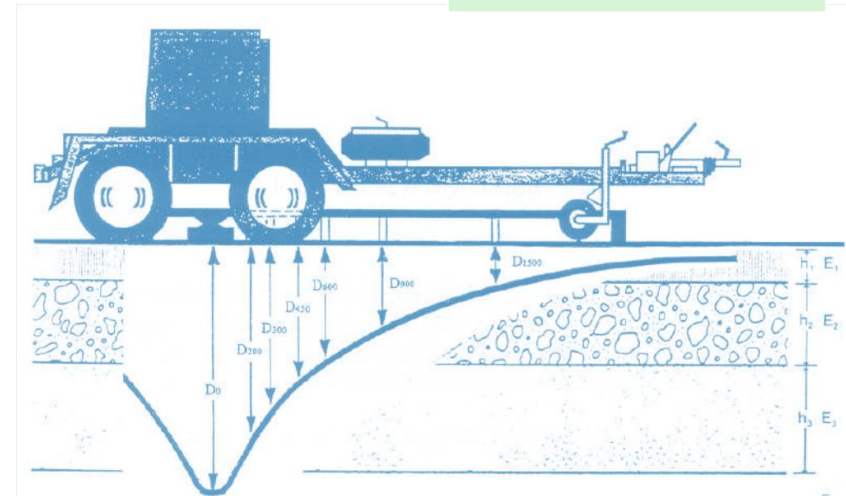
APMS

Network Level

- Programming
- Planning
- Budget

Project Level

- Design
- Construction
- M&R



RATING STRUCTURAL CONDITIONS

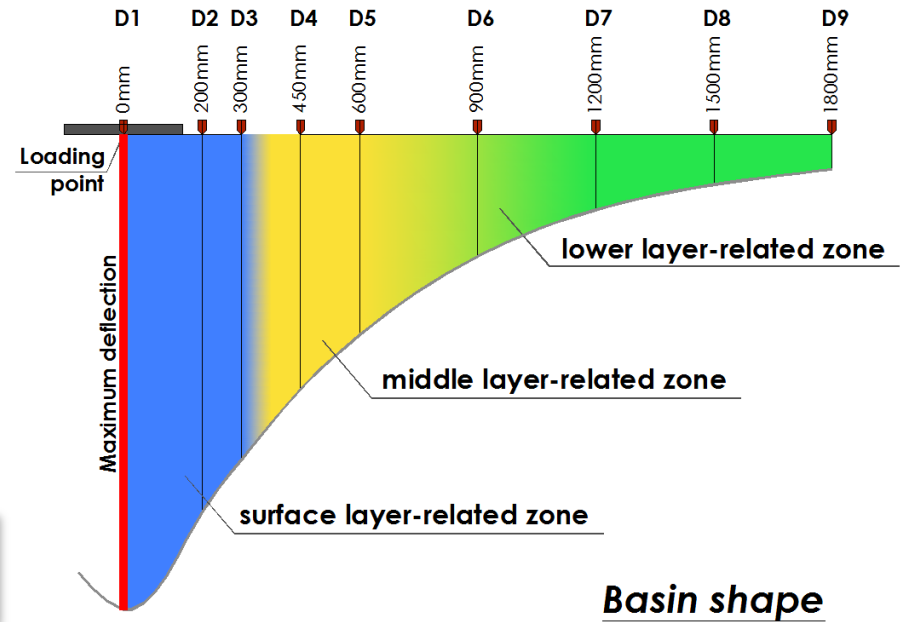
Research objective and scope

INVESTIGATION OF:

- OVERALL STRUCTURAL CAPACITY
- SINGLE LAYER PERFORMANCE



NETWORK LEVEL APMS



DEFLECTION COMPARABILITY?

SELF-RATING CONDITIONS PROCEDURE

Testing location

2013



1.99 M pax



28,000 mov



1.3 M tonnes

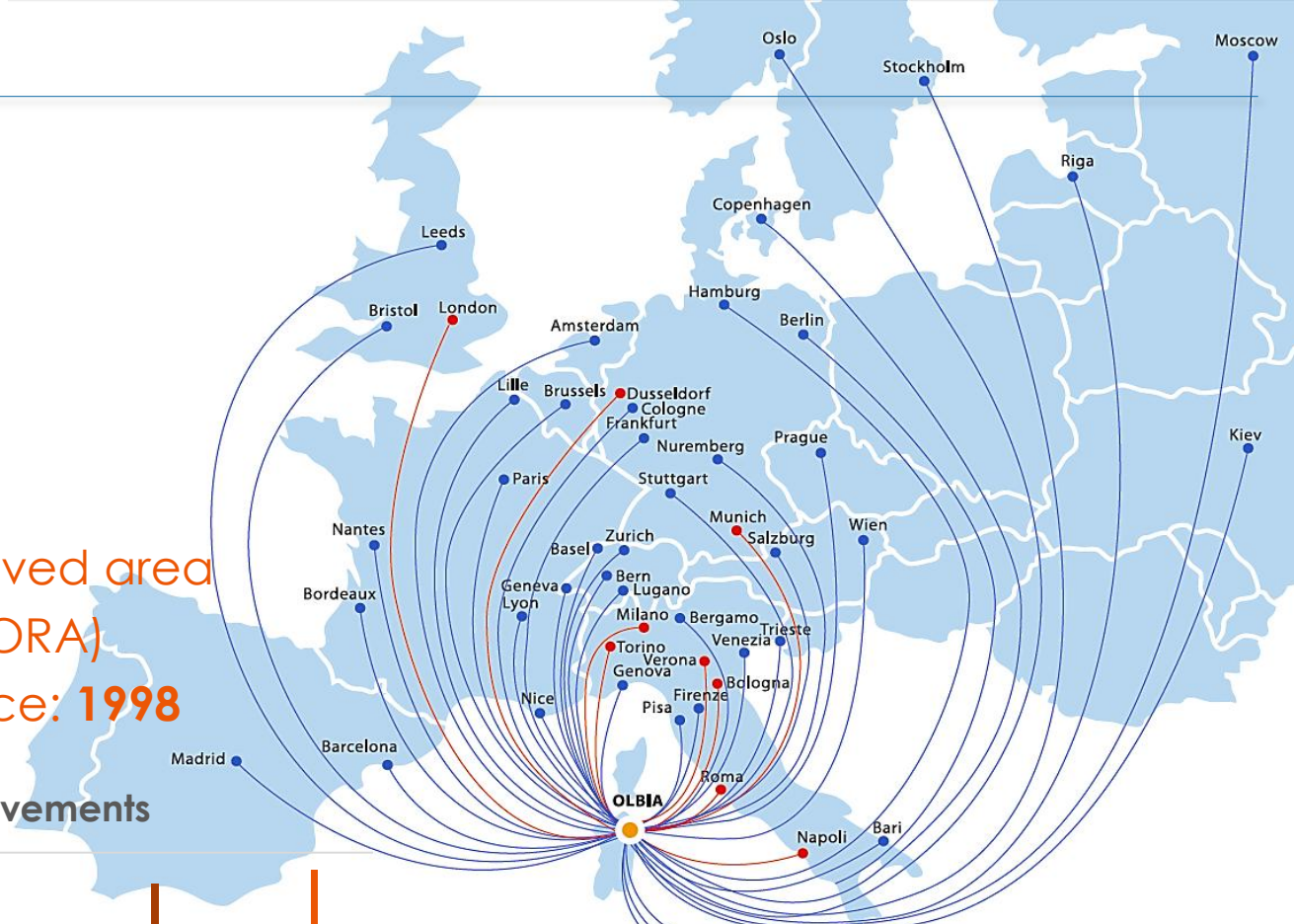
DIMENSIONAL DATA



457,000 sqm paved area

2,445 m RWY (TORA)

last maintenance: 1998



Monthly movements

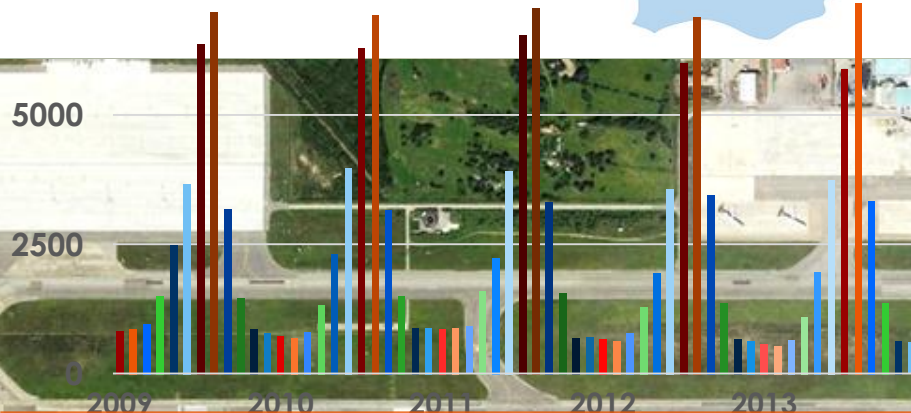
7500

5000

2500

0

2009 2010 2011 2012 2013



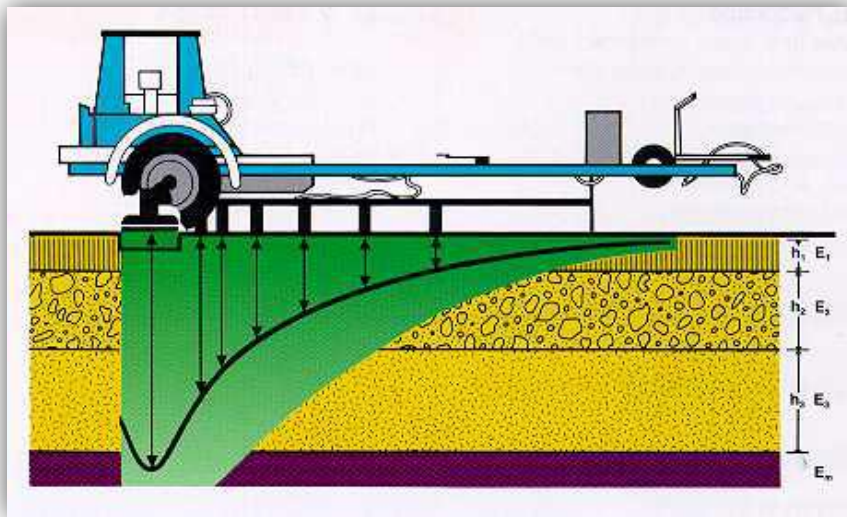
High Seasonality

June ► September ► Up to 73%

Tests conducted

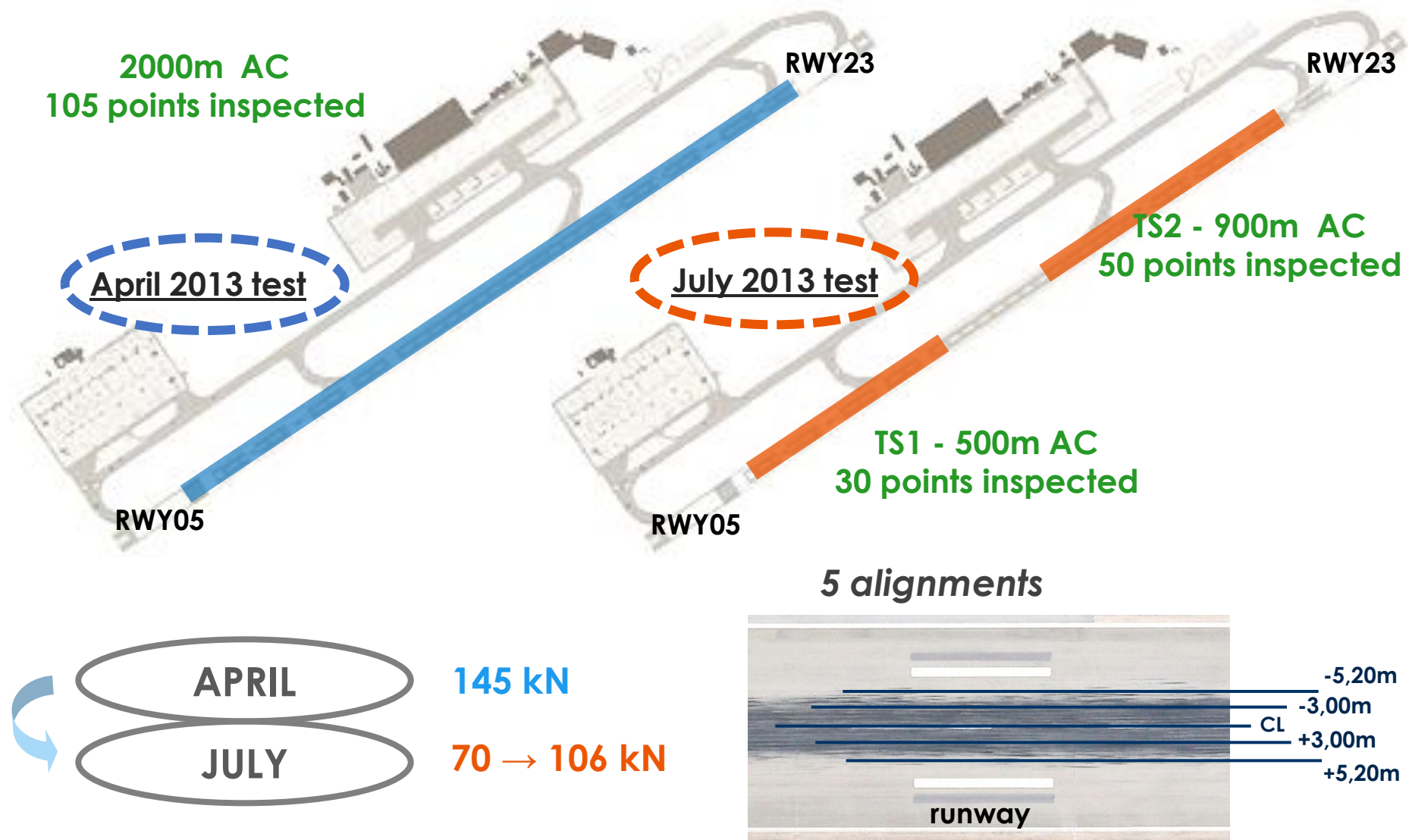
Heavy Falling Weight Deflectometer (HWD)

Standard method of
non-destructive evaluation
of airports pavements



Geophone	D1	D2	D3	D4	D5	D6	D7	D8	D9
Distance from center load (mm)	0	200	300	450	600	900	1200	1500	1800

Tests conducted



Data analysis

Layer investigation

- Surface layer < > E1
- Subbase < > E2
- Subgrade < > E3

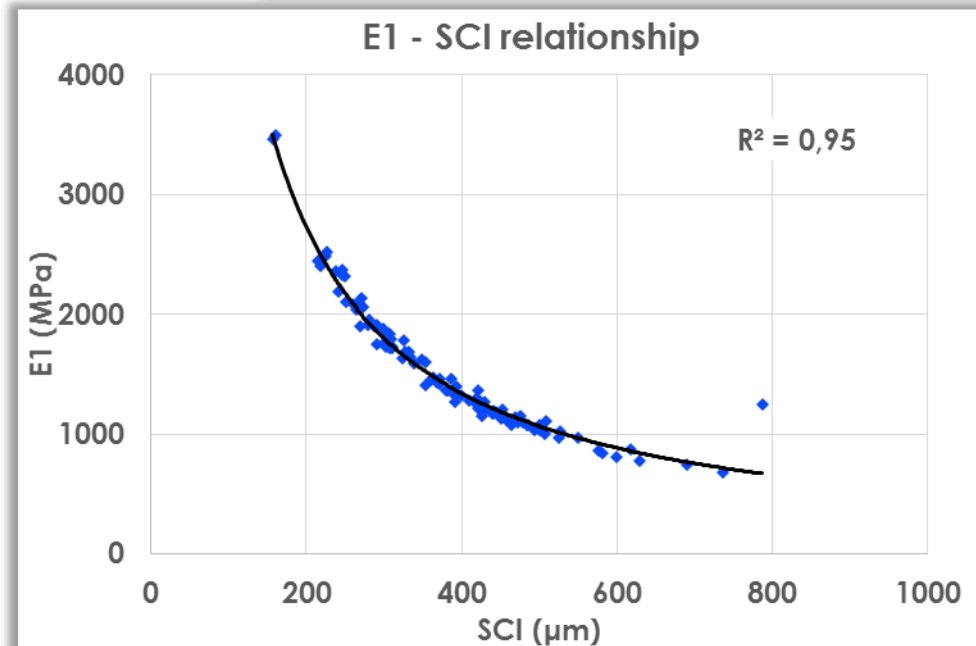
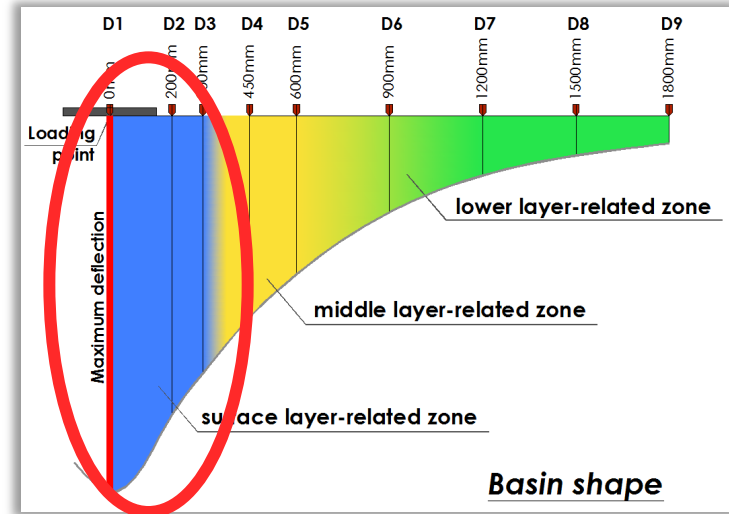
Back-calculation

- Coring inspections for E2, E3 assumptions

SURFACE LAYER

SCI = D1 (0mm) – D3 (300mm)

$$E1 = 629629 (SCI)^{-1,03}$$

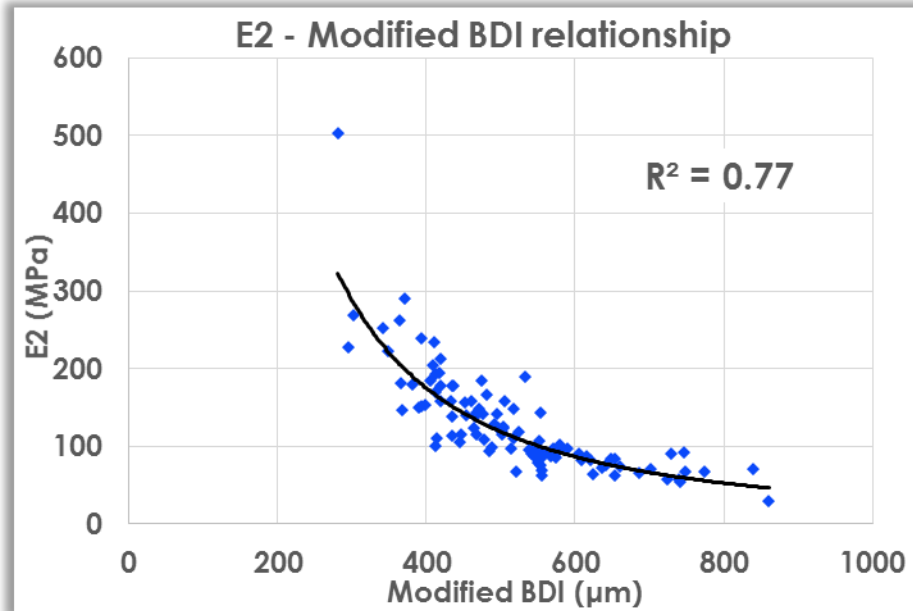
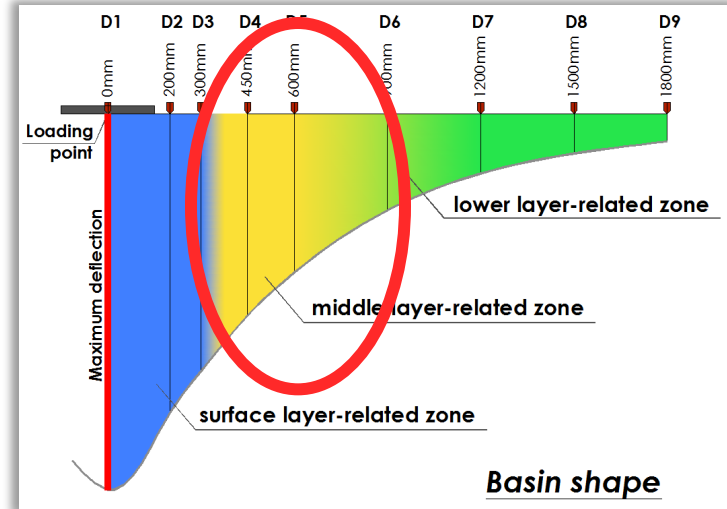


SUBBASE LAYER

$$\text{Modified BDI}^* = D3 (300\text{mm}) - D6 (900\text{mm})$$

(*) Donovan & Tutumluer

$$E2 = 5663607 (\text{Modified BDI})^{-1.73}$$

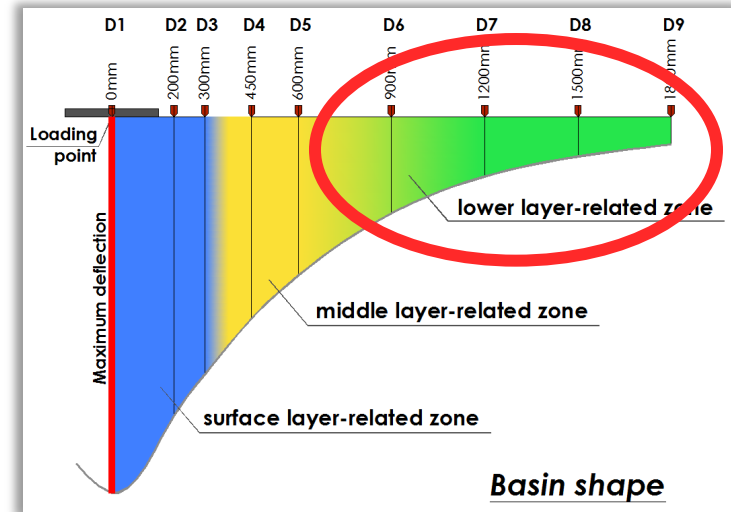
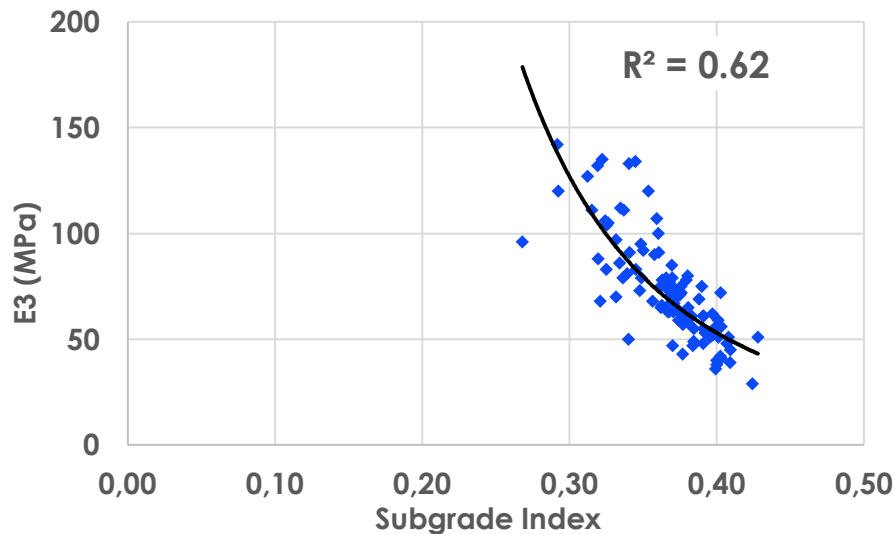


SUBGRADE LAYER

$$SI = \frac{D6 (900\text{mm}) - D8 (1500\text{mm})}{D5 (600\text{mm})}$$

$$E3 = 3.30 (SI)^{-3.03}$$

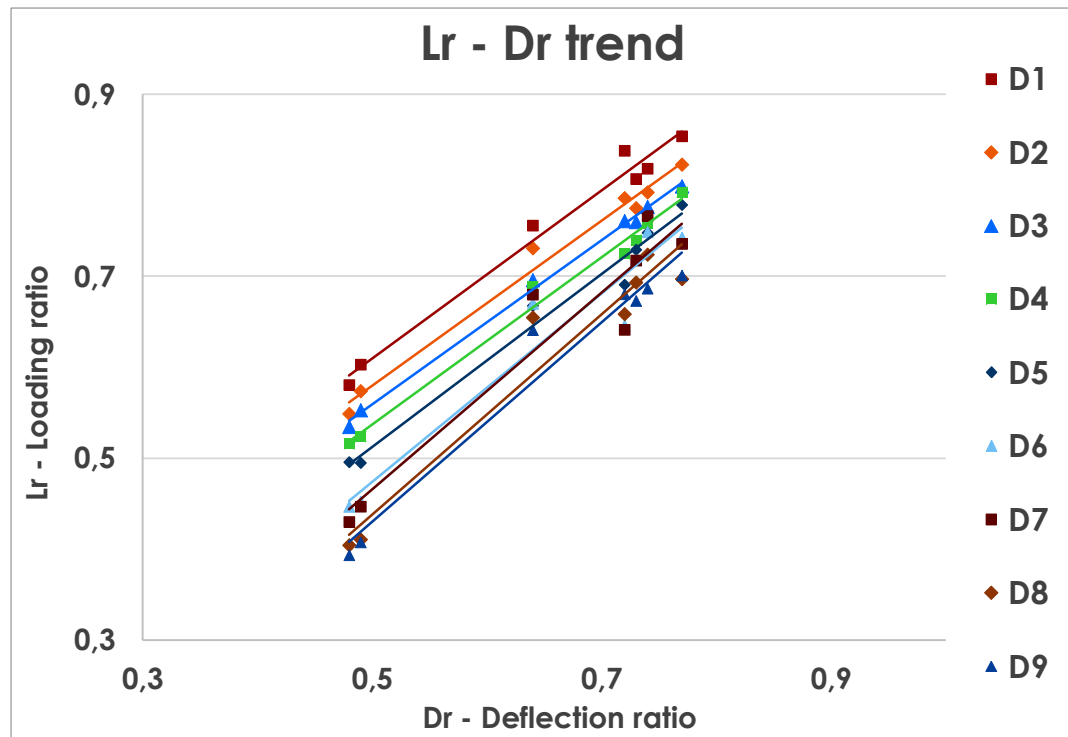
E3 - Subgrade index relationship



DATA COMPARISON?

$$Lr = (\text{Load}_{\text{july}}) / (\text{Load}_{\text{april}})$$

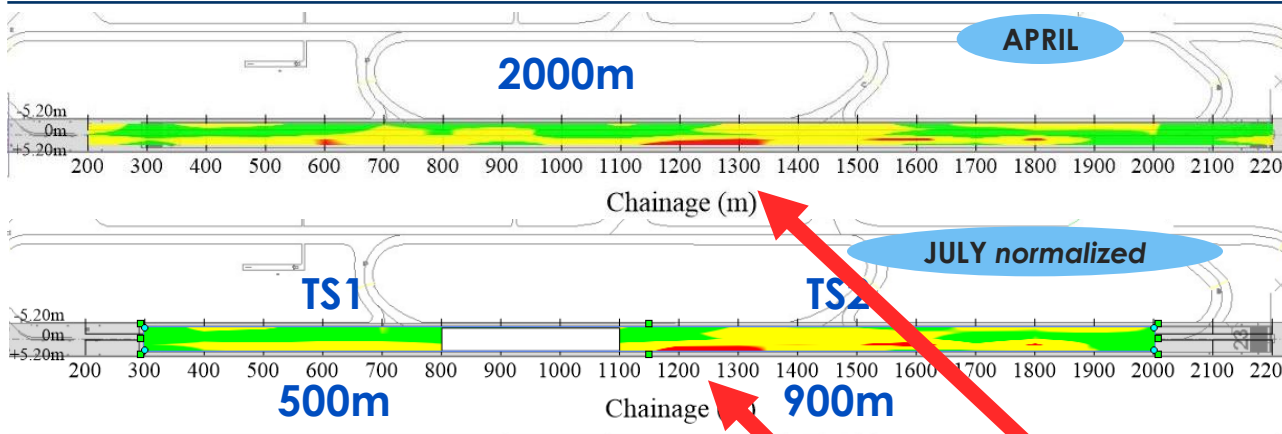
$$Dr = (\text{Deflection i-geophone}_{\text{july}}) / (\text{Deflection i-geophone}_{\text{april}})$$



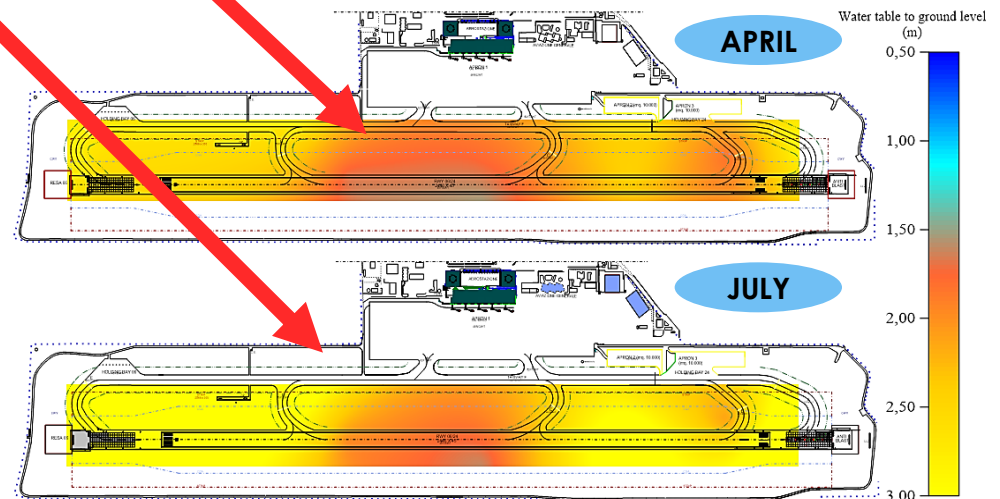
Benchmarking application

Pavement	Structural condition rating	D1 (drop weight 145kN)
HMA with Bituminous Base	Acceptable (Green)	< 1200 (μm)
	Warning (Amber)	1200 - 1600 (μm)
	Severe (Red)	> 1600 (μm)

D1
MAX DEFLECTION



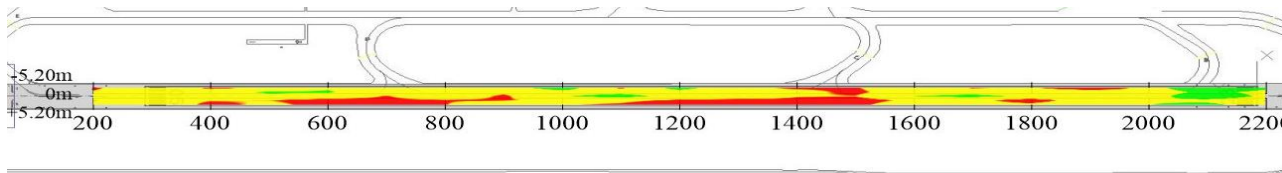
Water table investigations



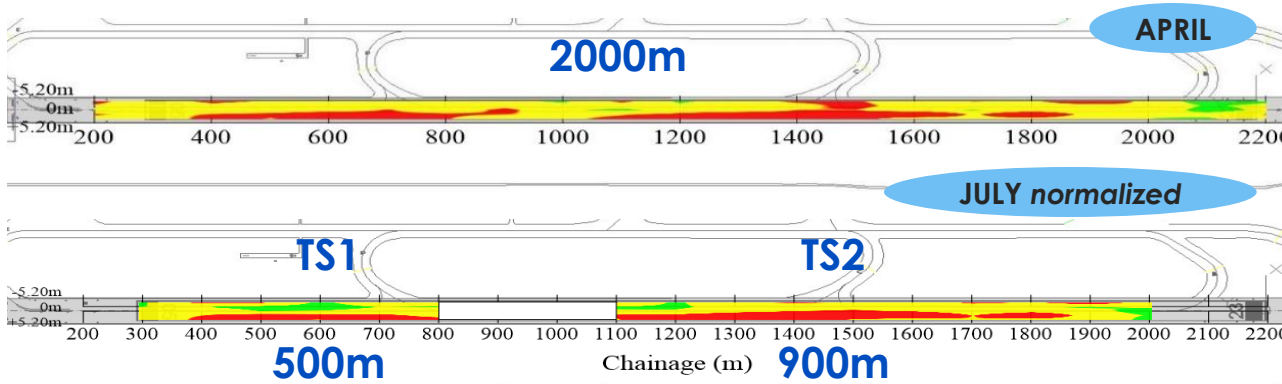
Benchmarking application

Layer	Structural condition rating	E1 (MPa)
HMA with Bituminous Base	Acceptable (Green)	> 2250 (MPa)
	Warning (Amber)	2250 - 1250 (MPa)
	Severe (Red)	< 1250 (MPa)

HMA layer
properties

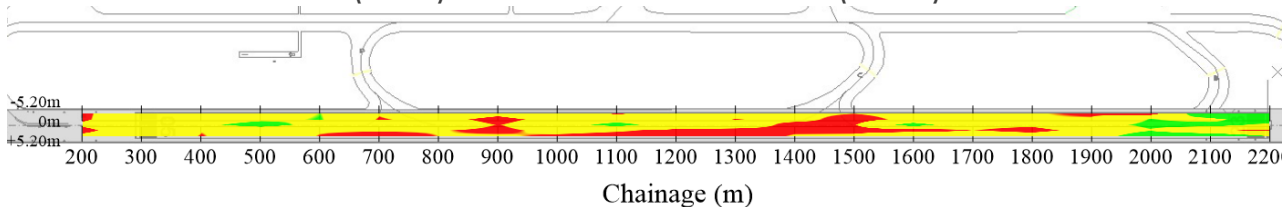


Layer	Structural condition rating	SCI (drop weight 145kN)
HMA with Bituminous Base	Acceptable (Green)	< 245(μm)
	Warning (Amber)	245 - 425 (μm)
	Severe (Red)	> 425 (μm)



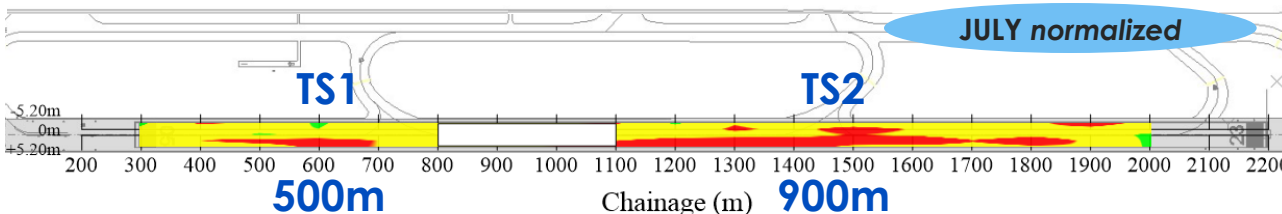
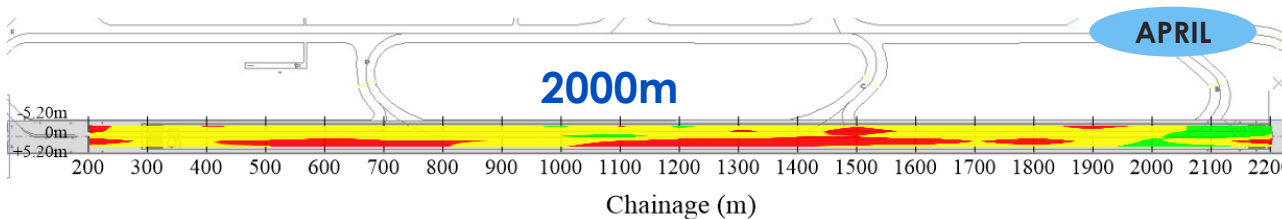
Benchmarking application

Layer	Structural condition rating	E2 (MPa)
Subbase	Acceptable (Green)	> 200 (MPa)
	Warning (Amber)	200 - 100 (MPa)
	Severe (Red)	< 100 (MPa)



**Granular
subbase
properties**

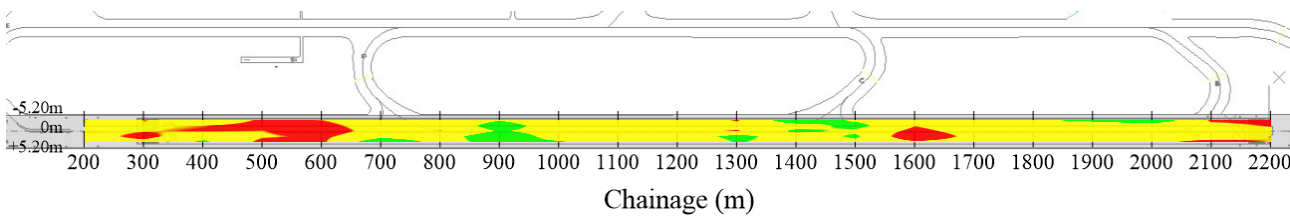
Layer	Structural condition rating	Modified BDI (drop weight 145kN)
Subbase	Acceptable (Green)	< 375 (μm)
	Warning (Amber)	375 - 565 (μm)
	Severe (Red)	> 565 (μm)



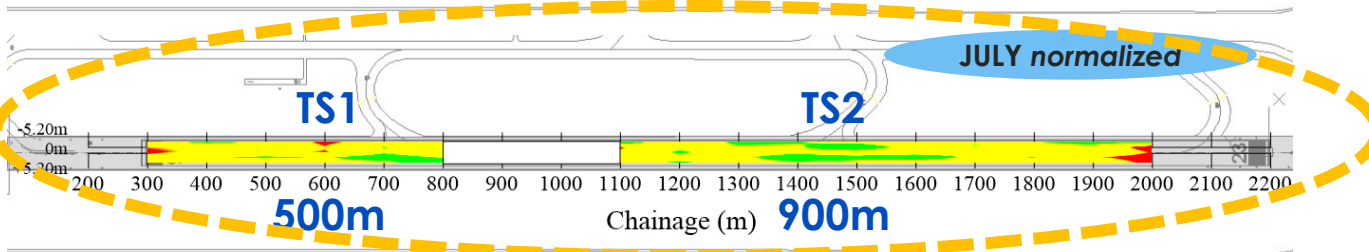
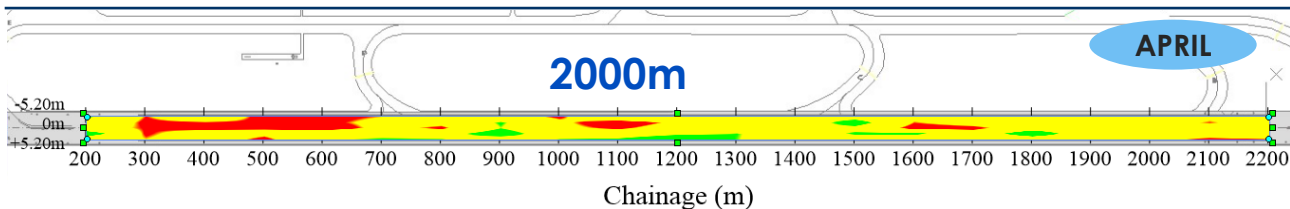
Benchmarking application

Layer	Structural condition rating	E3 (MPa)
Subgrade	Acceptable (Green)	> 100 (MPa)
	Warning (Amber)	100- 50 (MPa)
	Severe (Red)	< 50 (MPa)

Subgrade properties



Layer	Structural condition rating	Subgrade Index (drop weight 145kN)
Subgrade	Acceptable (Green)	< 0.325
	Warning (Amber)	0.325 – 0.340(μm)
	Severe (Red)	> 0.340 (μm)



Conclusions

- ▶ The pavement condition rating has been conducted implementing 4 indexes:
 - D1 maximum deflection → OVERALL CONDITIONS
 - SCI → HMA
 - Modified BDI → SUBBASE
 - Subgrade Index → SUBGRADE
- ▶ The selection of benchmarking values for implementation on APMS network-level has been conducted directly linking deflections parameters with the layer moduli obtained from back-calculation
- ▶ Investigating both *Dr* and *Lr*, having experienced temperature and moisture variations, the normalization has been conducted assuming different relationship for the geophone inspected

Conclusions

- ▶ In this investigation higher stiffness of subgrade layer on summer season has been found possibly related to lower water table level, highlighting the need of a drainage system improvement
- ▶ For pavement management purposes uniform conditions throughout years about season and temperature are suggested
- ▶ The use of contour plots representation in conjunction with the benchmarking methodology allows the immediately visual identification of critical areas as well as helping to define homogeneous sections



Thank you for your attention!

